SPC/Inshore Fish. Res./BP 67
14 March 1988

ORIGINAL : ENGLISH

SOUTH PACIFIC COMMISION

WORKSHOP ON INSHORE FISHERY RESOURCES
(Noumea, New Caledonia, 14-25 March 1988)

The Fiji deep-water snapper fishery — its development and management requirements

by

A.D. Lewis, A. Sesewa and T. Adams

Introduction

1. Development of the fishery for deep-water snappers on the outer reef slopes of Fiji's many islands and reefs has occurred rapidly since 1985, mainly to supply export markets with air-freighted chilled fish at premium prices. This rapid expansion, combined with the suceptibility of these valuable demersal fisheries to over-exploitation and continued oversees interest in the resource, has introduced at an early stage the need for the assessment of available stocks within the EEZ and provision of management advice. This paper reviews the development of the fishery, its salient features and describes attempts to provide a basis for rational longterm management of the fishery.

History of the development

2. Although fisheries for deep-water snappers had existed in South East Asia and in other Pacific island countries, notably Hawaii, for many years, little interest had been shown in the resource in Fiji primarily due to the relative abundance of traditionally exploited reef and lagoon resources. During 1977-1980, Fisheries Division surveys using droplines and handlines established the presence of a range of deep-water snapper species in commercial quantities, and provided preliminary data on species' depth preference and spatio-temporal variations in catch and effort (Anon, 1978, 1979, 1980, 1981). Bottom longlining was briefly trialled before its discontinuation due to gear loss and shark predation.

3. These surveys were followed by visits of the SPC Deep Sea Fisheries Development Programme (DSFDP) in 1979 (Western Division: 11/1979-8/1980; Mead, 1980) and 1980 (Lau, Mead, in press), which produced good results using the wooden Samoan handreels more appropriate to small scale artisanal fisheries.

4. Despite these promising early results, the fishery was slow to develop. As snappers were unknown on local markets (to this day, Hawaiian names are used in the absence of any established Fijian vernacular names), prices obtained provided insufficient incentive for the extra commitment required for fishing beyond the reef. The Fisheries Division- built 9m FAO-design vessel was fitted with reels which were often not well constructed, extension follow-up was inadequate for fishermen with little or no experience in this mode of fishing and management was often poor. Larger vessel owners did not feel catch rates obtained at that time could support a commercially viable operation for them.

5. In 1985, fish were air-freighted chilled to the Honolulu Market for the first time, with the support of the Fisheries Division and the SPC DSFDP, on its third visit to Fiji (Mead, in preparation). Prices obtained were variable, but generally encouraging, and attempts were made to collect for export, catches from a growing number of 9 m vessels. Despite coordination difficulties, this system has continued and during 1986, these exports, supplemented with some larger vessel catches (see later), comprised 6.8% of bottom fish lots auctioned at the Honolulu wholesale market (Ralston and Kawamoto, 1987).

6. Larger vessels experimented at this time with a variety of methods (eg pole droppers) but could not achieve wholly satisfactory catches given their higher overheads. In 1985, an estimated 20 tonnes of snappers were exported and 49 tonnes sold through local outlets.

7. In December 1985, a JICA-funded survey of fishery resources within the Fiji and Tuvalu EEZ's turned its attention to experimental bottomfishing, using a bottomline with over 1000 hooks set once per day (Anon, 1987). During the period December 1985-November 1986, 55 sets were made at an average catch of 327.6 kg/set, with a hook rate of 12%. This immediately generated considerable interest (Lewis, 1986) and two of the larger (>15 m) local vessels modified this experimental gear, using fewer hooks and making more sets per day. Catches of up to 600 kg per day were soon achieved, but heavy gear losses and bait requirements prompted one vessel to switch to hydraulic reels , based on Hawaiian techniques. Similar catch rates were achieved. 1986 exports climbed to 80 tonnes (estimated) with local sales approximated 45 tonnes.

8. As many fishing areas are over 100 nm from the nearest port facilities, further expansion of the fishery into these areas (> 50% of suitable habitat-see later) was constrained by the lack of suitable local vessels. The fishery had now attracted considerable overseas interest, and several proposals were received, including one to initially bring in 10 vessels up to 470 GRT in size with a catch target of 7,400 t. pa. This would increase to 25 vessels in the 3rd year. Fortunately, approval for this proposal was denied.

9. Approval was however given for two 20 m Hawaiian vessels to fish in specified more remote areas, under lease to a local company. By the end of 1987, one had departed, whilst the other was still fishing, along with four larger local vessels (one longline, three dropline) and a number of 9 m vessels. Total catches of up to 10 tonnes/week were achieved, but the fishery suffered numerous setbacks during 1987, mainly due to airline schedule disruption in the wake of political events. An estimated 125 tonnes were exported in 1987, and 35 tonnes sold locally (not including the very popular offcuts (heads and bellies) from processed export fish).

10. Some uncertainty attends the future of the fishery, but the devaluations of the Fiji dollar during 1987 have increased incentive to export. Many areas remain unfished or lightly fished and new seamounts continue to be discovered.

Fishery characteristics

Gear used

11. All but one of the larger vessels use hydraulic reels (4-5 per vessel) with 5 or more hooks per line. Skipjack, usually undersized or reject fish purchased from the PAFCO cannery, is used as bait.

12. Key elements in the operation of the large vessels are the use of a palu (chum) bag and anchoring in deeper water at selected localities. Depths of 150-200 f (270-360 m) are most often fished. The 9 m vessels, with few exceptions, use wooden Samoan handreels, and either drift or hang off the leeward side of reefs , usually fishing in 60-100 f (10-180 m).

13. The one longline vessel makes one or occasionally two sets per day (200 hooks), in 350-380 m using skipjack bait.

Species composition

14. More than 30 species are commonly taken in the deep-water snapper catch, similar to catch composition recorded in nearby areas (eg Vanuatu- Brouard and Grandperrin, 1985; PNG- Chapau, 1986; Tonga -BP 33, this workshop), but considerably more diverse than the Hawaiian (Ralston and Kawamoto, 1987), Marianas (Polovina, 1987) and Johnston Atoll deep bottom fish fauna (Ralston et al, 1986).

15. Species composition of the deep-water snapper catch varies with depth, area (mainland vs. seamount), type of gear (dropline vs. longline), time of day and possibly seasonally (see, for eg. Brouard and Grandperrin, 1985). Two peaks in catch rates by depth have been noted in some surveys (eg Anon, 1981), and these generally correspond with the depths fished by the smaller 9 m vessels with manual reels (60-100 f) and the larger vessels, with hydraulic gear or longline haulers targeting on Etelis spp (150-200 f).

16 The commercial catch data (not yet analysed) reflect targeting on Etelis spp in deeper water, and contain a higher percentage of these species. Only 8 species categories are recognised (Appendix 1).

17. The commercial longline catch for the period Jan.-June 1987 has been analysed, the catch of 34.5 t. comprising, by weight, 80.8% Etelis carbunculus, 7.2% E. coruscans and 12.0% others (mostly squaloid shark,gempylids, carangids, and Pristipomoides). This compares with the EEZ survey catch composition, covering a much wider depth range, of E. carbunculus (26.1%) and E. coruscans (20.0%), Anon (1987).

Catch rates

18. Few data are as yet available from the fishery. Much information has been collected from the largest vessels and is awaiting analysis. No data are available from the 9m vessels, other than during SPC DSFDP surveys. Preliminary catch rates for the longline operation (200 hooks) are 405 kg/set, with an average soak time of 11.1 hours.

Resource biology

19. Apart from clarification of the taxonomic status of problem species groups, which rendered earlier work in Fiji and limited value (Anon, 1980), little or no effort has been directed to biological studies of the major deep-water snapper species. This is in large part due to the undertaking of such studies in Fiji at the Institute of Marine Resources, USP. These data are currently awaiting publication. Recently, however, some biological work has been initiated as part of a of stock assessment programme (see later).

20. There are, in addition, comprehensive biological data on most species available from nearby Vanuatu (Brouard and Grandperrin, 1985), as well as from Hawaii and elsewhere (see Polovina and Ralston, 1984). It is not clear how transferrable some of the critical parameters (eg. $L\infty$, Lm, K) are between areas.

21. The red snapper, Etelis carbunculus, provides a case in point with regard to $L\infty$/Lmax. The species rarely attains more than several kg in weight in Hawaii (Ralston and Kawamoto, 1987), the Marianas (Polovina et al., 1986) and the Cook Islands (Dashwood, pers. comm.), whereas sizes in excess of 10 kg are regularly obtained in Vanuatu (Brouard and Grandperrin, 1985), Fiji (see later), Tonga and Samoa (Mead, pers. comm.). E. coruscans shows less apparent variation in $L\infty$, most estimates in the range 85-95 cm (Table 1). Brouard and Grandperrin (1985) however report a maximum size of only 75 cm LCF in a catch of 23 tonnes of fish caught on virgin seamounts. Fiji fishermen claim that seamount onaga (E. coruscans) never attain large sizes, and regard them as different on the basis of morphological criteria (eye size, caudal fin length). This is not supported by taxonomists (Anderson, pers. comm.).

22. Grimes (1987) notes that Lm (length at which 50% of individuals of a species are mature) as a percentage of L max varies between islands and continental populations and with habitat depth. Island populations tend to spawn year round with peak activity in late spring, summer and autumn, whereas continental populations tend to have a more restricted spawning period (usually summer).

23. The value of the generic approach for the preliminary estimation of some parameters eg. M, given K (Ralston, 1987) and Lm given Lmax (Grimes, 1987) has been demonstrated.

24. There are little or no data available on stock structure of deep-water snapper populations. Larvae of eteline lutjanids are found primarily in oceanic conditions rather than over continental shelves (Leis, 1987) and are thus more susceptible to dispersal. Shaklee (1984) found no evidence of genetic structuring in Pristipomoides filamentosus populations throughout the Hawaiian archipelago despite obvious discontinuities in adult habitat over the 2400 km range. It is probable that Fiji snappers can be regarded as a unit stock for management purposes.

Stock assessment

25. In response to the urgent need for an assessment of stocks of deepwater snappers, a strategy based on the methodology developed by Polovina (1987) has been followed ie:

1- collection of large length frequency samples of the main species from the fishery (which can be assumed to be exploiting virginal stocks at this time) to derive estimates of L∞ and Z/K.
2- collection of otoliths and time-series length frequency data to refine estimates of K, L∞ and M.
3- collection of catch and effort data from the fishery.
4- possible intensive fishing experiments to obtain estimates of q (catchability)
5- Ultimately, yield per recruit analyses.

26. The assistance and advice of NMFS (Honolulu) staff in developing this approach is gratefully acknowledged.

Length frequency

27. The catch was sampled from the larger vessels, during preparation of the catch for export. As the fish were headed and gutted for export (to save on freight costs), it was a relatively simple matter, with the cooperation of fishermen, to interpose a sampler in the processing line. The entire catch was measured in most cases. Care was taken to ensure that all fish caught were measured, since small individuals, particularly of Etelis spp, were rejected for export, and other species eg. Wattsia, Paracaesio were not always exported.

28. Sampling was initiated in May 1987 and was continued on an intensive basis until the end of September. Over 1400 fish were measured (Table 2). The species composition is felt be representative of the total catch of the larger vessels, which fish in deeper water (300m plus) and target on Etelis spp. Seven species (Etelis,2; Pristipomoides,2; Aphareus, Paracaesio, Wattsia) accounted for 93% by number of the total sample.

29. Figures 1 to 4 show the total length frequency distribution of these species, most of which approximate the expected linear attenuation in numbers in unexploited stocks for sizes > lc. Aphareus rutilans however is not fully recruited to the fishery until a relatively large size (80 cm LCF or approximately 7 kg). This may be somehow related to its more midwater feeding strategy.

30. Estimates of Z/K and $L\infty$ have ben provided by NMFS ,Honolulu, based on a programme developed by Weatherall (1986), and using data collected to the end of July,.(ehu, n=2370; onaga, n=1093). Assuming at this very early stage in the development of the fishery that Z/K approximates M/K and Lm is 50% $L\infty$, the following estimates of length at capture which maximises yield per recruit, from tables of the Beverton-Holt yield equation, were obtained for F= 0.5 M and F=M respectively (Polovina, pers. comm.) :.

E. carbunculus	38.0	43.1	(Ir =38)
E. coruscans	36.1	39.7	(Ir =39)

31. Thus the current length at capture more or less maximises the yield per recruit at light to moderate levels of fishing effort. Similar analyses will gradually be done for other species.

Age and growth

32. Although facilities and expertise to age snappers using daily growth checks in otoliths are not available in Fiji, it is possible that such analyses maybe be undertaken in the future. On this basis, 50-100 otolith pairs are being collected from 8 species (Etelis, 2; Aphareus; Paracaesio; Wattsia; Pristimopoides,3), with all parts of the size range equally represented.

33. In the interim, estimates for most species are available from Vanuatu (Brouard and Grandperrin, 1985).

Intensive fishing experiments

34. Data from the intensive fishing over 3-4 days are available from one of the larger dropline vessels fishing newly discovered seamounts in Southern Lau. These might be amenable to derivation of estimates of population size and catchability coefficient (q), but have yet to be analysed.

Estimates of yield

35. Whilst it is hoped to ultimately derive estimates of equilibrium yield for the fishery from either total biomass models or from assessments based on Beverton-Holt yield equations, this will be take some time, particularly with the former approach. As detailed earlier, preliminary estimates of equilibrium yield are required with some urgency in Fiji.

36. Yield assessments of deepwater snapper stocks in the Marianas and Hawaii (Polovina, 1987) have been expressed in terms of yield per unit of fish habitat, in this case the 200 m isobath, a measure appropriate to the sleep-sided outer reef slopes characteristic of much of the region. Estimates of 222.4 kg/nmi of 200 m isobath (95% confidence interval 165.3 - 279.6 kg/nmi) for the Marianas and 272 kg/nmi for Hawaii were obtained.

37. The length of the 100 f isobath, an approximation to the 200 m isobath, was roughly measured from available neutical charts using a wheel counter, to provide initial ball-park figures. Not including seamounts, an estimate of 2024 nmi was obtained for the Fiji EEZ. Using an upper estimate of yield of 270 kg/nmi, an equilibrium yield of 547 mt/year, excluding seamounts, results.

38. Following Brouard and Grandperrin (1985) and anticipating that initial catches can be expected to be approximately twice those at equilibrium yield, this equilibrium yield figure was doubled and an addition made for the large number of seamounts within Fiji's EEZ, to produce an estimated initial yield of 1400 mt/year.

39. The JICA EEZ survey (Anon, 1987) produced an estimate of total demersal fish population (including sharks and by-catch) of 4,900 tonnes for Fiji waters, excluding Western Viti Levu and Rotuma. Based on catches in an area of habitat (200-500 m) roughly estimated at 1260 km2, an estimate of "allowable annual catch" (total nett annual weight increase of the population) of 1200-1600 tonnes.

40. Using a recently acquired digitiser, the nominal exploited deepwater snapper habitat (100-400 m) was re-measured more accurately from 1:150,000 scale bathymetric charts with 100 m depth contour intervals. Known seamounts were also included. The area within this depth zone was estimated at 3300 nmi2 and the length of the 100 m and 400 m isobaths respectively as 2780 and 3210 nm respectively. The 200 m isobath length is thus considerably larger than original estimate (by nearly 50%, presumably due to the precise following of contours).

41. All the above estimates are preliminary and essentially "quick and dirty". There are several reasons for believing that the equilibrium yield figure used (270 kg/nmi) may be an underestimate for Western Pacific high island snapper populations. Consideration of species fished shows that a suite of shallower water species, including Paracaesio (2 spp), Wattsia, Etelis radiosus and some Pristimopoides (multidens, flavipinnis), is either rare or absent from Hawaiian/Marianas catches. In addition, the more diverse species assemblage appears to be distributed over a considerably wider depth range. This possibility needs further investigation.

42. Direct estimates of standing stock have been made for Etelis spp. on seamounts within the New Caledonia EEZ where trawl surveys were carried out. Brouard and Grandperrin (1985), using the formula MSY=0.5 MB0 where B0=unexploited biomass, calculated an MSY of 3.7 kg/ha/yr, which is approximately 8 times the equilibrium yield per ha/yr calculated from the Hawaiian/Marianas figures. Seamounts must be regarded as a special case, being much more productive on a unit area basis than reef slopes, but the estimates do need reconciling.

Management

43. Faced with the prospect of up to ten large vessels with the stated intention of catching 7000 mt being given approval to commence fishing in Fiji waters, the Fisheries Division was obliged to prepare for Government consideration, an interim management plan for the fishery.

44. Produced in May 1987, this incorporated the following considerations:-

i A maximum permitted catch of 1000 tonnes for the years 1987 and 1988, or until such time as a more accurate yield estimate is available (the figure, arbitrary and somewhat conservative in the light of the lack of hard data available, was based on the estimated initial yield (for the first few years of the fishery) of 1400 mt for the whole of the Fiji EEZ, including undiscovered seamounts.

ii Limitation of effort, with provisions to

a- recognise the pioneering role of local vessels and protect their future requirements

b- safeguard the interests of small vessel local fishermen with a limited operating radius from the main population centres.

c- commitment by the Fisheries Division to further refine scientific yield assessment.

45. Effort was arbitrarily limited to 8 vessels in the 15-20 m range (estimation annual catch of 100 t/yr), with no limit on smaller vessels (<15 m). It was also argued that vessels larger than 20 m have little place in the present fishery, because of the strict market requirements for fresh fish and hence trip lengths of 10 days or less.

46. Options to increase local value added were identified for possible future consideration. Provision of catch details was also required.

47. Prior to the development of this Management Plan, which was accepted by Government as a working guideline, leased foreign vessels (2) had been restricted to an area in the east and south of the Fiji Group, outside the operational area of smaller vessels, but with large areas of the unexploited snapper habitat, and well within the customary operating range of these vessels in the North-West Hawaiian islands.

48. As a the end of 1987, development of the fishery had slowed markedly following political events and their impact on air freight availability and other logistical considerations.

References

ANON (1978) Fisheries Division. Annual Report 1977. MAF, Fiji. 58p.

ANON (1979) Fisheries Division. Annual Report 1978. MAF, Fiji. 136p.

ANON (1980) Fisheries Division. Annual Report 1979. MAF, Fiji. 116p.

ANON (1981) Fisheries Division. Annual Report 1980. MAF, Fiji. 99p.

ANON (1987) The Fisheries Resources Survey in Fiji and Tuvalu. Vol 1, 110p., 10 plates. Vol. 2 (Figures and Tables) 126p. Japan International Cooperation Agency.

BROUARD, F. and R. GRANDPERRIN (1985) Deep-bottom fishes of the outer reef slope in Vanuatu. 17th RTMF, Noumea, July 1985. Working paper 12. 127p.

GRIMES, C.B. (1987) Reproductive biology of the Lutjanidae: A review p239-294. In : POLOVINA, J.J. and S. RALSTON (eds) Tropical snappers and groupers: Biology and fisheries management. Westview Press. 659p.

LANGI, V.A. and S.A. LANGI (1987) A stock assessment programme on the bottom fishes of the seamounts. Kingdom of Tonga: The first 9 months. Fishbyte Dec. 1987:6-11.

MEAD, P.D. (1980) Report on the visit of the South Pacific Commission, Deep Sea Fisheries Development Project (DSFDP) to Fiji (8 November-13 December 1979 and 13 March-1 September 1980). SPC December 1980. 21p.

MEAD, P.D. (in press) Report of second visit to Fiji, 1 September to 9 October 1981 and 19 February to 13 April 1982. SPC, DSFDP, SPC. Noumea.

MEAD, P.D. (in preparation) Report of third visit to Fiji (18th January 1984-24 April 1985). Deep Sea Fisheries Development Project..SPC, Noumea.

LEIS, J.M. (1987) Review of the early life history of tropical groupers (Serranidae) and snappers (Lutjanidae).p189-237. In : POLOVINA, J.J. and S. RALSTON (eds) Tropical snappers and groupers: Biology and fisheries management. Westview Press. 659p.

LEWIS, A.D. (1986) Bottomlining in Fiji creates great interest. SPC Fish. Newsletter 37 : 31-36.

POLOVINA, J.J. , R.B. MOFFITT, S. RALSTON, P.M. SHIOTA and H.A. WILLIAMS (1985) Fisheries resource assessment of the Marianas archipelago, 1982-85. Mar. Fish. Rev. 47(4): 19-25.

POLOVINA, J.J. (1987) Assessment and management of deep-water bottom fishes in Hawaii and the Marianas. p505-532. In : POLOVINA, J.J. and S. RALSTON (eds). Tropical snappers and groupers: Biology and fisheries management. Westview Press. 659p.

RALSTON, S. (1987) Mortality rates of snappers and groupers. p375-404. In : POLOVINA, J.J. and S. RALSTON (eds). Tropical snappers and groupers: Biology and fisheries management. Westview Press. 659p.

RALSTON, K. and K.E. KAWAMOTO (1987) An assessment and description of the status of bottom fish stocks in Hawaii. SWFC Admin. Rept. H 87-7. 55p.

SHAKLEE, J.B. and P.B. SAMOLLOW (1984) Genetic variation and population structure in a deep-water snapper, Pristimopoides filamentosus in the Hawaiian Archipelago. Fishery Bull. 82(4):703-713.

WETHERALL, J.A. (1986) A new method for estimating growth and mortality parameters from lenght-frequency data. Fishbyte April 1986:12-14.

Table 1 : Estimates of L_∞ and recorded maximum lengths (L max) for Etelis carbunculus and E. coruscans.

E. carbunculus	Countries	L_∞	Lmax
	Fiji	113.3	120
	Vanuatu	94.0	112*
	Tonga	-	114**
	Marianas	69.1**	-
	Hawaii (main is)	82.1***	-
	Hawaii (NWHI)	69.4***	-
E. corsuscans			
	Fiji	90.3	94
	Vanuatu	82	91*
	Tonga	99.3	96**
	Marianas	97.6**	-
	Hawaii (main is)	89.4***	-
	Hawaii (NWHI)	95.7***	-

* Brouard and Grandperrin, 1985
** Langi and Langi, BP 33
*** Ralston and Kawamoto, 1987

Table 2 : Snapper length frequency samples-numbers by species.

Etelis carbunculus	5088
E. coruscans	4022
E. radiosus	100
Aphareus rutilans	897
Paracaesio kusakarii	957
P. stonei	118
P. gonzalesi	6
Wattsia mossambica	763
Pristipomoides filamentosus	676
P. flavipinnis	368
P. multidens	272
P. typus	338
P. sieboldi	114
P. auricilla	18
P. zonatus	71
Serranids	89
Seriola spp.	210
others	18
Total	14125

Deep-water snapper daily catch log

Appendix 1

(CONFIDENTIAL)

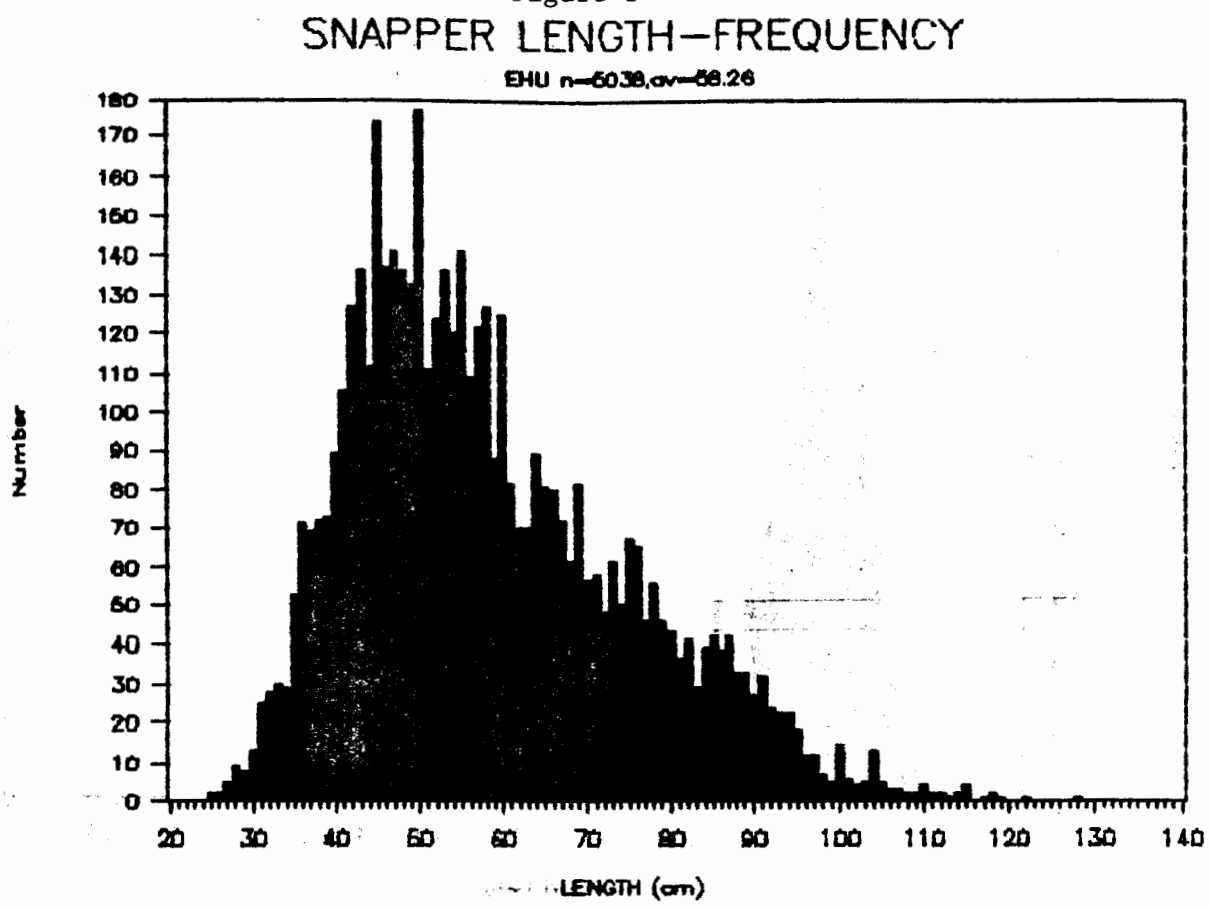
DEEPWATER SNAPPER - TRIP REPORT

(CONFIDENTIAL)

Vessel: ______________ GRT: ______ Captain / F. Master: ______________

DATE D / M / Y	GRID POSITION (CODE)	TOTAL HOOKS	FISHING TIME (HOURS)	AVERAGE DEPTH (M)	NO. OF SETS OR SHIFTS	BAIT TYPE	EHU (KG)	ONAGA (KG)	LEHI (KG)	PAKA (KG)	BEDFORD (KG)	BREAM (KG)	COD (KG)	SHARK (KG)	OTHER (KG)	TOTAL (KG)
TOTALS																

Figure 1


SNAPPER LENGTH–FREQUENCY
EHU n=6038,av=68.26
Number
LENGTH (cm)

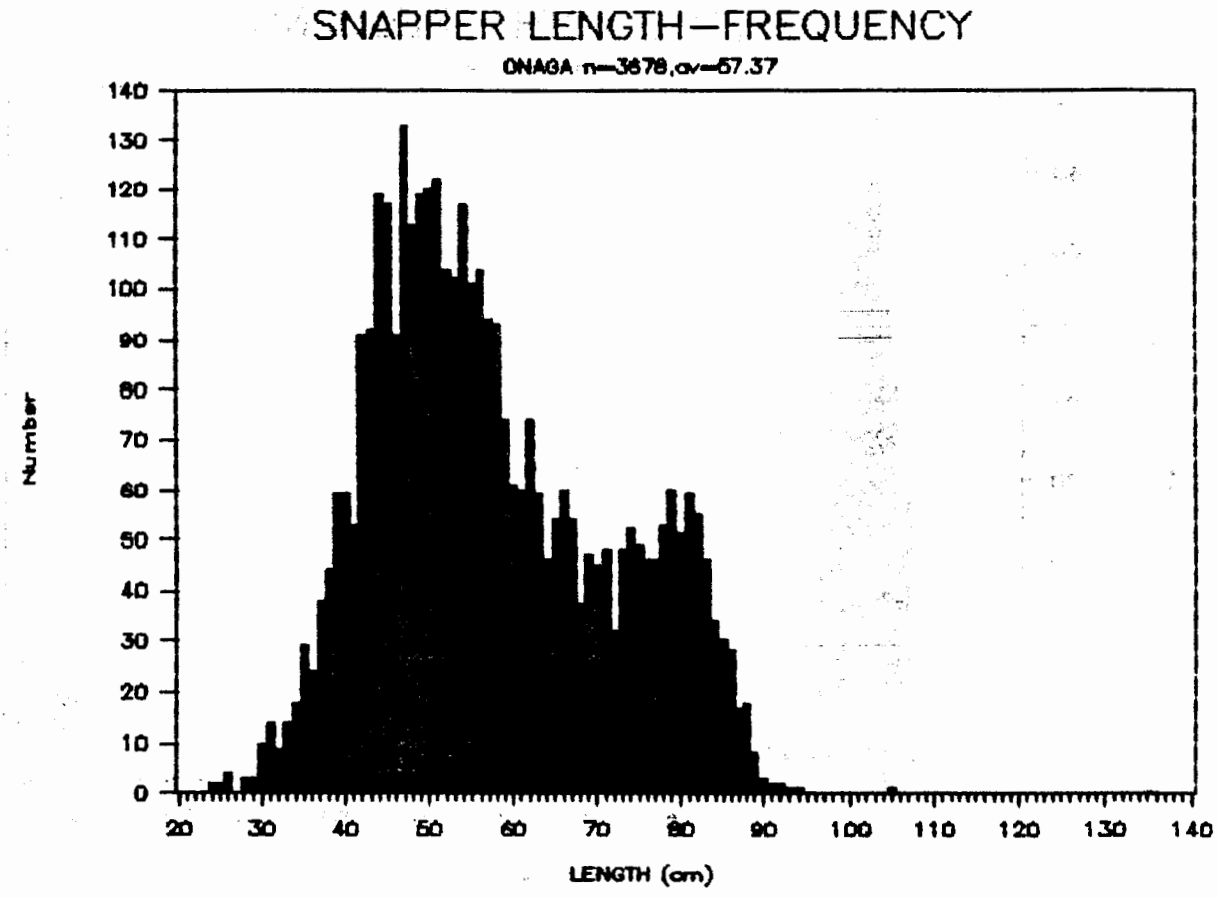
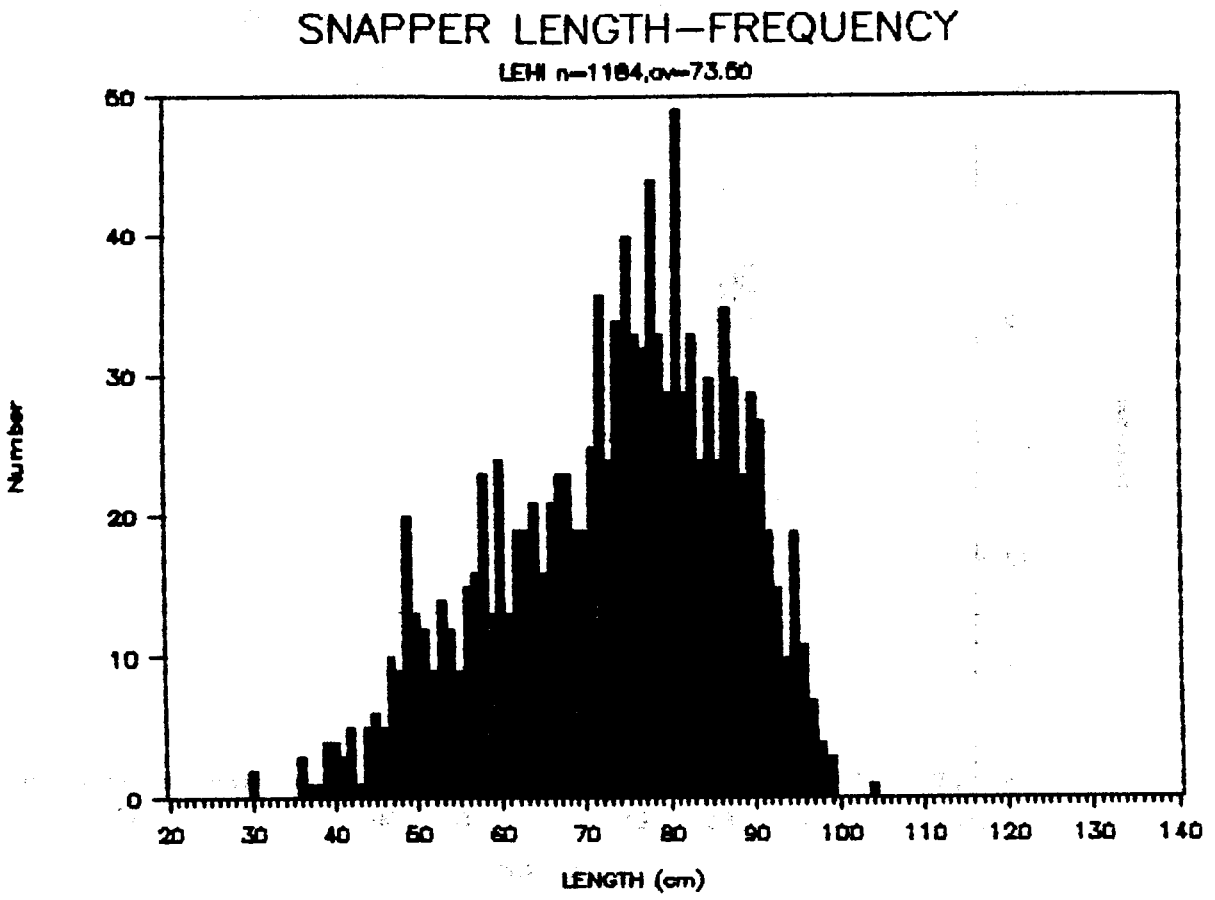

SNAPPER LENGTH–FREQUENCY
ONAGA n=3678,av=67.37
Number
LENGTH (cm)

Figure 4


SNAPPER LENGTH—FREQUENCY
LEHI n=1184,av=73.60
Number
0
10
20
30
40
50
20
30
40
50
60
70
80
90
100
110
120
130
140
LENGTH (cm)